Aqueous and non-aqueous sol-gel preparation of TiO_2 films for the photocatalytic oxidation of ethanol in air

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Introduction

Photocatalysis is successfully applied to environmental remediation.

The photocatalytic activity of TiO_2 as well as its physico-chemical stability, self-cleaning property and high selectivity make it a suitable candidate for the removal of hazardous pollutants such as VOCs from contaminated indoor atmosphere.

The **sol-gel process** is widely used to obtain porous and homogeneous TiO_2 and it allows to control the stoichiometry and work in mild and ambient atmospheric conditions.

The aim of this study was to synthesize TiO_2 sols by two different sol-gel methods (aqueous and non-aqueous) and to evaluate the influence of different solvents and different concentrations of hydrolyzing agent on the photocatalytic activity of the films.

Aqueous sol-gel

TiO_2 sols were synthesized using titanium tetraisopropoxide (TTIP) as precursor and nitric acid in water as hydrolyzing agent.

Three different solvents (ethanol, isopropanol and butanol) and two different molar ratios HNO_3 /TTIP (0.25 and 0.5 respectively) were used in order to evaluate the best film preparation conditions (films A-F).

Non-aqueous sol-gel

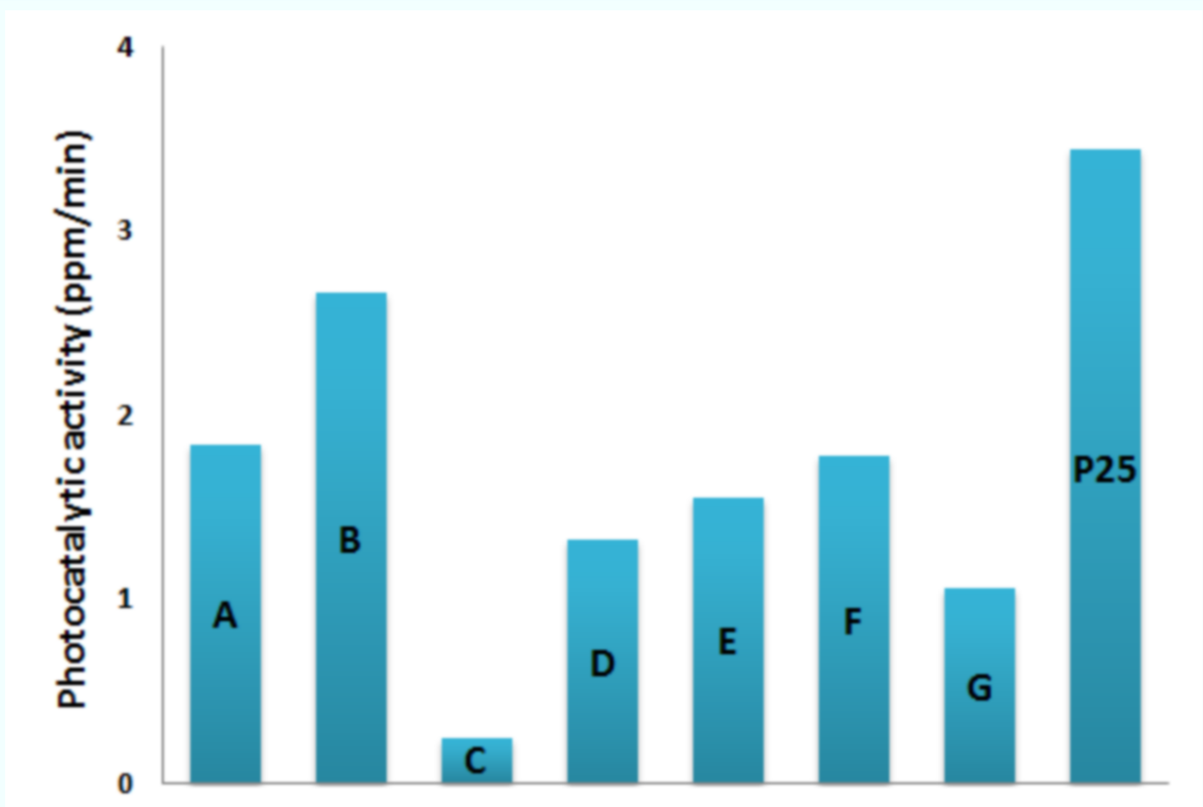
Titanium tetraisopropoxide was used as precursor and the hydrolysis was initialized by esterification reaction between acetic acid and ethanol. Acetylacetone was added as chelating agent (film G).

Films produced by consecutive spin coating of 4 layers were heat treated at 450°C for 2 hours and tested in the breakdown reaction of ethanol as VOC molecule under UV and visible light.

Photocatalytic measurements were carried out in a stainless steel batch reactor, in a controlled Ar/O_2 atmosphere, by means of an atmospheric gas analyser containing a mass spectrometer [1].

Results

Sample	Solvent	HNO_3 /Ti precursor ratio	d_{XRD} (nm)	SA_{XRD} (m^2/g)	SA_{BET} (m^2/g)	d_{BET} (nm)	Photocatalytic activity (ppm/min)
A	EtOH	0.25	63	25	‹ 5	-	1.84
B	EtOH	0.5	37	41	‹ 5	-	2.67
C	iPrOH	0.25	60	25	‹ 5	-	0.25
D	iPrOH	0.5	36	42	19	76	1.32
E	BuOH	0.25	151	10	50	30	1.55
F	BuOH	0.5	62	25	23	67	1.78
G	EtOH	—	90	18	35	44	1.06
P25	—	—	25	61	56	27	3.44



Conclusions

- A higher concentration of HNO_3 led to smaller crystallite size and hence to a higher photocatalytic activity.
- The aqueous sol-gel films, except for sample C, showed a higher photocatalytic activity than the non-aqueous sol-gel film.
- The aqueous sol-gel process in which ethanol has been used as solvent (samples A-B), led to highly active films if compared with TiO_2 films prepared from Degussa P25.

References

[1] K. Eufinger et al., J. Phys. D: Appl. Phys. 40 (2007) 5232

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